
Why Medicine Needs Agriculture

IRWIN L. GOLDMAN

*University of Wisconsin
Madison, WI*

According to some cultures, the practice of healing and the phenomenon of divine retribution have their roots in horticulture. Eve's transgression in the mythical, biblical Garden of Eden has manifold consequences; among them, pain in childbirth and the burden of knowing evil along with good. Tempted by the fruit from the tree of knowledge in a garden planned for divine sustenance of a people, Eve's act serves as an appropriate metaphor for the double-edged sword that nature represents. On the one hand, plants represent a bounty we depend on for the maintenance of health, while, on the other, they can cause great harm if used improperly. Taken one step further, appropriate use of the garden of nature leads to eternal health and happiness, whereas misuse leads to misfortune. Regardless of the path we take, the recognition that plants have the ability to cause harm and to prevent it stands at the center of the connection between agriculture and medicine.

MEDICINE AND RELIGION

In fact, prehistoric recognition of the curative and harmful powers of plants and plant extracts served as the beginning of the practice of medicine and of the sciences of horticulture and botany (Janick, in press). Priests and physicians, who were charged with healing, depended entirely on their knowledge of the plant kingdom for curatives. For thousands of years, medicine and religion were practiced interchangeably by healers and religious figures who sought healing from spiritual cures and magic, as well as from living organisms in the natural world. Magic and healing were, and continue to be in some circles, inseparably linked. Janick (in press) has pointed out that the Egyptian word *pharagia*, which means making magic, is the origin of the Greek *pharmakon* and Egyptian *pharmaki*, both of which serve as the origin of the word pharmacy.

Although superstition ruled the practice of medicine for many thousands of years, widespread adoption of the scientific method, and the accumulation of

experimentally based knowledge, transformed medicine into a scientific discipline. This took place in approximately the seventeenth century, when botany and horticulture, as well as medicine, took on the look of modern, scientific disciplines (McCollum, 1957). Medical texts from this period began to de-emphasize plant-based remedies, even though they continued to be in widespread use (Janick, in press). For most of the world's cultures, the primary source of medicinals has been, and continues to be, plants. Current estimates are that more than 70% of medicines are, or were, plant-derived (Janick, in press). The domestication of crops is inextricably connected with healing properties, as medicinal uses may have preceded their more widespread use as food (Smartt and Simmonds, 1995; Rubatzky and Yamaguchi, 1997).

The primary source of information on this close connection between agriculture and human health are documents known as "herbals." The herbal is the primary physical link between horticulture, medicine, and human health (reviewed in Janick, in press). For example, herbals testify to the myriad health-related properties that have been associated with alliums, such as onion (*Allium cepa*) and garlic (*Allium sativum*) (Block, 1992). The frequent descriptions and uses of garlic in herbals by Babylonians, Egyptians, Phoenicians, Vikings, Chinese, Greeks, Romans, and Hindus suggest that it is one of the most widely used plants in folkloric medicine (Block, 1992; Amagase *et al.*, 2001). The herbal combined information about medical remedies, botanical features, and horticulture; thus, it stands as the crucial link between these fields and demonstrates a lineage of close cooperation with respect to human health.

AFTER THE FALL: DIVERGENCE OF AGRICULTURE AND MEDICINE

Many of the medicinal properties described in folklore and, to some extent, verified by modern medical research, have their origins as plant protectants (Block, 1992). Secondary compounds are often associated with defensive functions in plants, and many of these compounds are of great interest today as phytonutrients (Goldman, in press). Flavonoids, carotenoids, terpenes, glucosinolates, isoflavones, thiosulfonates, *etc.*, may, through their inherent toxicity, confer resistance to pests (Drewnoski and Gomez-Carneros, 2000; Briggs and Goldman, 2002). However, the astringency and toxicity that may be important for survival are viewed widely by consumers as negative from a culinary point of view. Thus, agricultural practices, including plant breeding and post-harvest handling, have attempted to reduce or minimize the astringency of secondary compounds that affect flavor (Drewnoski and Gomez-Carneros, 2000). Crops of today may, therefore, be modified significantly from their earlier domesticated counterparts with respect to such phytonutrients (Goldman, in press). For this reason, it is possible that consumers today do not see the close linkage between crops and human health that may have been apparent to societies living more closely to the period of transition between hunting-gathering and agriculture.

It is often said that the United States is a nation of immigrants. Natural remedies for disease, based on plants and plant extracts and described in herbals, likely served as the basic medicine for many immigrants. Until the beginning of the twentieth century, herb-based remedies were the norm. The Old-World traditions of cultivation of herbs and other medicinal crops remained strong in many parts of the United States, and immigrants relied heavily on them for their healing properties. However, there was a marked shift away from traditional practices toward synthetic medicines during the latter half of the twentieth century (Lawson, 1998), as synthetic pharmaceuticals were developed through advanced chemical means. These synthetic monomolecular drugs became a focal point for the practice of medicine in the United States and many other parts of the developed world, leading to tremendous gains in public health. However, with the shift away from plant-based remedies came a loss of knowledge of their uses and efficacy (Goldman, in press). Although this knowledge was retained and even strengthened in Europe, it tended to disappear in the United States to the point that those born following World War II were far less inclined to turn toward food-based remedies for health concerns; instead they focused on the more widely available and highly efficacious monomolecular drugs (Lawson, 1998).

Development of the food-guide pyramid, the emergence of a national school-lunch program (Gunderson, 2001), strategies such as “five-a-day,” and promotional efforts of the United States Department of Agriculture have had some success in increasing public awareness of the close connection between human health and nutrition. However, nutritional content still takes a back seat to taste, convenience, and cost when it comes to the food preferences of Americans (Tillotson, 2002). Furthermore, food-based approaches to health, particularly those aimed at long-term disease prevention, carry little appeal. This is perhaps due to a long history of reliance on synthetic medicine, and to our collective impatience manifested by a desire to see immediate results and to spend less time purchasing, preparing, and eating food, coupled with the almost-irresistible appeal of highly processed foods.

WHAT WENT WRONG BETWEEN NUTRITION AND MEDICINE?

Heber and Bowerman (2001) stated that “the evolution of human dietary patterns has been driven by necessity, economics and more recently, by the selection of foods carefully designed and promoted on the basis of taste, cost, and convenience, often without regard to their nutritional and health value.” Despite this de-emphasis on health value, clear evidence exists for the lowering of risk for many chronic diseases, such as cancer, as a result of increased consumption of fruits and vegetables (Anonymous, 1997; Doll and Peto, 1981). Phytochemicals may be at the core of what is believed to be “health functional” about a diet rich in fruits and vegetables. Increased consumption of fruits and vegetables in the diet along with cessation of smoking and increase in exercise have the potential to reduce the incidence of a wide variety of ailments,

including cancer and cardiovascular disease. Thus, they should be of great interest to us, both in agriculture and in medicine.

Nutritionists have examined the effects of dietary patterns based on single properties, such as high fiber, low fat, or reduced carbohydrates. In certain cases, the consumption of a single compound such as β -carotene or lycopene was investigated, thereby reducing the diet to a single measurable property (Heber and Bowerman, 2001). It has been argued that simplified definitions of these dietary patterns led to the idea that supplementation may substitute for the value of a complex diet. For example, if a laboratory study indicated that β -carotene supplementation may be associated with health functionality, then it followed that a reasonable experiment was to supplement diets with this phytochemical in a large, clinical study. Unfortunately, those studies did not demonstrate that such supplementation was efficacious; and in some cases supplementation with phytochemicals proved to be hazardous (Anonymous, 1994). The negative, and at times hazardous, effects of single-chemical supplementation suggests that whole foods, rather than their purified constituents, may be responsible for some of the health functionality of plants. Further research during the latter part of the past decade has done little to convince scientists that simple supplementation is a clear path toward improving public health through nutrition.

Other strategies have focused on manipulating the ratio of the major nutritional constituents of food in order to achieve improved health. For example, low-carbohydrate diets such as Zone™ are predicated on the claim that food is a powerful drug (Sears, 1995). While there is a great deal of public debate about the efficacy of such diets, one of the take-home messages for the general public pertains to the interconnectedness of food and health; a message that is many millennia old. An interesting spin on such diets is their alleged fit with the busy professional's life style. Zone™ products, for example, are marketed with the slogan "nourishment for a time starved world."

As agriculture has developed around the world, dietary patterns have shifted from whole-food, plant-based diets to those that include large amounts of processed sugar, grains, and oils. Heber and Bowerman (2001) argue that the American diet is focused mainly on three grain-based ingredients: refined flour, corn sweeteners, and vegetable oil. In many developed countries, obesity and diabetes are reaching epidemic proportions, despite the widespread availability of inexpensive fruits, vegetables, and other basic unprocessed foods. As agriculture has become more productive, efficiencies have increased, thereby lowering prices, which has benefited consumers and users of basic agricultural products, but has hurt farmers by offering continuously decreasing financial rewards for their efforts. With the lowest commodity prices in several decades in the marketplace today, the supply of inexpensive fruits and vegetables in the United States is abundant and accessible. Nevertheless, demand does not appear to rise accordingly.

Clearly, human dietary patterns are governed to a large extent by taste and convenience, and to a much lesser degree by nutritional content. If epidemiological data indicate that many chronic diseases can be reduced significantly with increased consumption of fruits and vegetables, and the public does not willingly choose to increase its vegetable intake, is it any wonder that agriculture and medicine have become polarized?

VITAMIN DISCOVERY AND THE REEMERGING CONNECTION BETWEEN AGRICULTURE AND MEDICINE

The “biological era” in nutritional science began in the early part of the twentieth century and led to the recognition of specific elements of food and their functional properties, such as the discovery of vitamins (McCollum, 1957). This era marked a turning point in the relationship between agriculture and medicine. During the first decade of the twentieth century, agricultural scientists identified crucial constituents of foods, later known as vitamins, which were directly responsible for promoting and sustaining health. These discoveries were made on the campuses of land-grant universities, where agricultural and medical scientists worked in close proximity. In addition, there was a pressing need to improve animal nutrition through science, following in the footsteps of the successes of improving soil fertility through the pioneering work of agricultural chemists such as Justus Liebig.

The pioneering work of E.V. McCollum, a US Department of Agriculture employee at the University of Wisconsin, laid the groundwork for the discovery of vitamins (reviewed in Goldman, in press). McCollum made several important decisions in his research program that allowed these discoveries to take place. He was among the first to use rats instead of cows for research on nutrition, thereby greatly reducing the time and cost associated such experiments while increasing the potential for discovery. It is well known that the development of model organisms fueled the growth of many fields of science, and nutritional science was no exception. The purified diets McCollum used in his rat studies differed in only a single constituent, thereby allowing more-precise interpretations of experimental data. This came to be known as the method of biological analysis, which allowed more comprehensive and realistic analyses of food and its components in the animal diet than previous methods that focused solely on chemical composition. By feeding rats with purified diets, McCollum was able to unambiguously identify the important constituents for growth and sustained health (McCollum, 1957).

McCollum was the first to identify an important fat-soluble constituent of butterfat and egg yolk—which later became known as vitamin A—a water-soluble compound known as vitamin B, and his studies led to the discovery of vitamin D (McCollum, 1957). Although it had been known since perhaps the seventeenth century that a disease like scurvy could be caused by poor diet and cured by the addition of citrus fruit, the specific constituents were not

isolated until after McCollum's early work on vitamins A and B. By the 1920s, the specific causes of pellagra, rickets, and scurvy were attributable to vitamin deficiencies, and new support was found for the health-functionality of food.

These pioneering studies led to the discovery of many vitamins, opening up a new area of research in human nutrition. Agriculture and medicine had overlapping goals, thanks to the insightful work of these nutritional scientists. The role of vitamins also cleared the way for more concrete recommendations on the nutritional impact of vegetables. Marketing efforts were constructed with vitamin content in mind, thereby promoting a science-based value-added commodity to the public.

AGRICULTURE AND SPIRITUAL HEALTH

Even though it provides the basic minerals, nutrients, water, and physical properties for plant growth and, thereby, for the sustenance of humanity, the soil is not only a source of physical health. It has been argued that a connection to the soil, whether through agricultural labor or other natural practices, is at the very core of the sustenance of the human spirit and is the foundation for human civilization. The name Adam, our biblical first human, is derived from *adama*, which means earth in Hebrew, suggesting that human culture is inextricably linked to the soil. Today it is obvious to us that the basic mineral elements of nutrition are literally from the earth. Thus, if the old adage “you are what you eat” is correct, we are made up of the soil and possess a very unique literal connection to the earth.

However, beginning with the rise of modern agriculture about 10,000 years ago, societal development has pushed the human population gradually away from direct contact with the soil. The largely rural population of the United States at the turn of the twentieth century has been whittled down to a very small fraction. Only 1.5% of the general population lives on the farm and are involved directly in food production.

Many environmental movements have urged a rekindling of a close connection with soil, with mixed success. In the nineteenth century, the transcendentalist movement in New England was based on the fundamental truth of this connection. Articulated by Henry David Thoreau in *Walking* in 1862:

I wish to speak a word for nature, for absolute freedom and wilderness, as contrasted with a freedom and Culture merely civil, to regard man as an inhabitant, or a part and parcel of Nature, rather than a member of society. I wish to make an extreme statement, if so I may make an emphatic one, for there are enough champions of civilization; the minister, and the school-committee, and every one of you will take care of that.

Although from a political point of view it would seem that acknowledgement of environmental issues has made great strides since the 1970s, it does not appear that the general public has a greater appreciation for the close connection between soil and human health. Thus, one could argue that the tremendous success of modern agriculture has come with significant costs to our spiritual health.

To the extent that modern medicine recognizes the crucial connection between mind and body, it is possible that significant inroads to improved human health could be made through an emphasis of our primal relationship with the soil. A number of modern-day efforts aim to build this bridge, including programs for community gardens in urban centers and food-assistance vouchers for the poor and elderly that can be redeemed only at farmer's markets. However, our culture has a long way to go before such bridges are readily crossed by the great majority of Americans.

FUTURE RELATIONS AND COALESCENCE

Medicine, horticulture, and botany have been closely linked since the pre-historic discoveries that certain plants are capable of healing and others are harmful. Priests and physicians were the first practitioners of the healing arts, based both on empirical work with plants and on a belief in magical substances with curative powers. With those discoveries, the fields of agriculture and medicine were closely wedded, supported by documents known as herbals that testified to the myriad uses of plants and their extracts to prevent, treat, and cure disease. In addition, the widespread practice of agriculture formed the foundation for a supply of food for the growing world population. Thus, agriculture and medicine were inseparable for many millennia. This close connection persisted until the seventeenth century, when scientifically based medicine became prominent, and medical treatises began to de-emphasize horticultural practices. From that point on, agriculture and medicine began to separate. As crucial discoveries of vitamins and minerals were made during the early part of the twentieth century through collaborations of agricultural and medical scientists, the two fields became reunited and it appeared that there was much common ground on which to build. However, the rising dependence on synthetic monomolecular drugs in the developed world resulted in a reduced dependence on the cumulative wisdom on plants and human health. In many cultures, such information was lost over a period of several generations.

Today, we are again interested in the relationship between food and health, from the point of view of food functionality. The functional food delivers some physiological benefit beyond nutrition, and thereby confers the possibility of both sustenance and health to the consumer. Given this definition, it is certainly possible that all food is functional, and it is only our limited understanding of its properties that prevents us from labeling it as such. On the other hand, our search for individual functional properties may prevent

us from seeing a larger, more holistic relationship between food and health that can be viewed only through the lens of a complex diet. Certainly, the simple fact that our relationship with the soil is a fundamental truth of human nature should encourage us to pursue the integration, rather than the separation, of agriculture and medicine. The minerals in the soil that form some of the most important aspects of our physical nature are indicative of the importance of this relationship. We can no longer afford to separate the two disciplines that started in unity and are waiting to coalesce for the sake of our healthy future.

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